

Australian

Summer Issue Volume 15 Number 4 2007

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# DEFENCE SCIENCE



**Keeping the Army Tigers drier**

**Hypersonics technology flies high**

**Setting fuel tank on fire for safety's sake**

**Flight control upgrade for *Nulka***

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE <b>2007</b>		2. REPORT TYPE		3. DATES COVERED <b>00-00-2007 to 00-00-2007</b>	
4. TITLE AND SUBTITLE <b>Australian DefenceScience. Volume 15, Number 4</b>				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Australian Government,Department of Defense,Defense Science and Technology Organisation,Australia,</b>				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release; distribution unlimited</b>					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>Same as Report (SAR)</b>	18. NUMBER OF PAGES <b>14</b>	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			

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**Australian Government**

**Department of Defence**

Defence Science and  
Technology Organisation

The Defence Science and Technology Organisation (DSTO) is part of the Department of Defence and provides scientific advice and support to the Australian Defence Organisation. DSTO is headed by the Chief Defence Scientist, Dr Roger Lough, and employs about 2200 staff, including some 1300 researchers and engineers. It is one of the two largest research and development organisations in Australia.

Australian Defence Science is published quarterly by DSTO Defence Science Communications. Unless labelled copyright, material may be reproduced freely with acknowledgement.

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ISSN 1441-0818

# A drier Tiger is a healthier flyer

The Army's new Tiger Armed Reconnaissance Helicopter (ARH), soon to be permanently based at Robertson Barracks in Darwin, faces a greatly increased threat of corrosion in the wet tropics environment of its new home. DSTO is looking into ways of reducing this threat with dehumidified hangar facilities.

DSTO researcher Peter Trathen says, "While many parts of the Tiger are made from composite materials that do not corrode, its construction includes a significant number of metal items, such as various structural components, the magnesium alloy gear box case and numerous connectors in the avionics systems, that are susceptible.

"When considering ways to alleviate this problem, we looked at the benefits of providing shelter for the aircraft and dehumidifying their hangars. Corrosion rates can be reduced to extremely low levels if humidity can be reduced to below 40%."

Trathen says the advantages this offers in terms of enhanced operational availability and reduced through-life support costs are considerable..

## Dehumidification system on trial

In August this year, testing was conducted by personnel from DSTO and the Armed Reconnaissance Helicopter Project Office on a prototype hangar-to-aircraft interface for the dehumidification system.

"The dehumidification system, which was already installed and ready for use, is located in a plant room and feeds dried air through large diameter ducts to a row of hangars, with each hangar housing a single Tiger," explains Trathen.

Temporary ducting was connected from the hangar outlet to a distribution manifold, and from this, a number of smaller ducts were run to supply dehumidified air to different parts of the helicopter.



*Top and inset: Tiger ARH helicopter in hangar with dehumidification apparatus.*

The parts of the aircraft included in testing were the cockpit, transmission compartment, the electrical bay at the forward end of the fuselage, and the main avionics section.

Data loggers for measuring temperature and humidity were placed inside the airframe in several locations to measure the air distribution and the change in humidity levels that the supply of dried air made in comparison to a measure of ambient conditions.

## Dry success for test outcomes

After each test run, the data was downloaded and analysed.

Testing showed that dry air was able to fully penetrate the structure in a short time. The work also provided data on the air flow paths, and indicated the optimum places for attaching ducts to aircraft.

The test results have supplied the Army ARH Project Office with the data it needed to complete the final design of interfaces for the dehumidification systems.

Designing appropriate base facilities (hangars and wash/rinse systems) is part of the Environmental Degradation Management process being introduced by the Aircraft Structural Integrity section of the RAAF Directorate General Technical Airworthiness.

This work is supported by DSTO as part of the task for 'Assessment and Control of Aircraft Materials Degradation' to examine the causes of corrosion and the range of possible solutions.



# ANZACS declared fit for long life at sea

Since the early 1990s when the RAN's ANZAC class frigates first took shape in the shipyards, much more has been asked of them in terms of the weight and workload they are required to carry. DSTO recently completed a study of the effects of these factors on the structural integrity of the vessels.

According to DSTO researcher Bernie Phelps, changing operational and capability requirements for the ships have seen a steady weight growth since their introduction into service in 1996, together with an increase of up to 60% in the time at sea compared to original design estimates.

"The effect of these changes is an operational profile that is vastly different to the one originally specified, meaning that it has become necessary for the hull structural design to be re-evaluated in order to maintain the certification baseline of seaworthiness," he says.

An extensive program of work was undertaken to evaluate the additional loading to be borne by the ships, and then to determine the impacts of this on the global strength and fatigue performance.

The analysis was carried out under tight time constraints to permit the development of modification work packages in time to meet the schedule requirements of an Anti-Ship Missile Defence (ASMD) upgrade planned for the ANZACs.

## Mathematical tool for the study

Phelps explains that the work was conducted using two main mathematical modelling techniques: the 'panel-method' for the prediction of loads, and the 'finite element' method to calculate the structural response to the applied loads.

"The panel-method uses what is known as 'potential flow theory' to calculate the fluid pressure for various wave conditions over a large number of discrete panels representing the under-water hull surface," he says.



"These pressures are then integrated over the entire surface to determine the forces and 'moments' of force on the structure.

"Using the finite element method, the structure is then represented as a geometric framework of discrete elements with associated structural properties. The elements are linked to each other by mathematical equations that determine the response to





Photos both pages: RAN ANZAC class frigates at sea.

the applied forces and moments. These can be varied, depending on the conditions being simulated, to determine how the different areas respond.”

At the start of DSTO’s study, an existing finite element model of the ANZACs was first verified to ensure that it could reliably replicate the results of the original design calculations. This model was shown to be acceptable from a global perspective, but later required modification when consideration was being given to more highly stressed areas in order to provide sufficiently detailed stress information for fatigue analysis.

The assessment of different ballast configurations and the panel-method evaluation of over 2,800 individual wave load cases were necessary to provide the lifetime extreme loads to be used in the finite element analysis. Around 20 ‘worst case’ loading scenarios were considered in the finite element analysis to determine the most highly stressed areas of the structure.

A detailed review and numerical evaluation of around 250 individual welded connections and major structural openings was then made to determine the likelihood of fatigue failure during the projected 30-year design lifetime.

### Certification for new operating requirements

A series of reports completed in August 2007 were provided to the ANZAC System Program Office and subsequently submitted to Germanischer Lloyd (GL), the German Classification Society that conducted the original structural design and is tasked to verify compliance of the ANZAC class with the requirements of the ship specification.

This approval was issued by GL in October 2007, allowing an increase in the Limiting Displacement by 300 tonnes to a total of 3,900 tonnes and for the full 30-year operational life, as originally planned for these vessels, despite the extra weight and additional time at sea each year.

The upshot of the work on the ASMD upgrade is that this is now cleared to proceed without the need for extensive structural modifications.





# Hypersonics technology takes to the skies over Woomera

A trial was carried out at the Woomera Test Range last year as part of a fundamental research program aimed at developing a revolutionary new form of air-breathing propulsion that could eventually attain velocities well above ten times the speed of sound.

The program, known as the Hypersonics Collaborative Australian and US Experiment (HyCAUSE) was undertaken jointly by the US Defense Advanced Research Projects Agency (DARPA) and the Australian Hypersonics Initiative (AHI), with DSTO, one of several AHI members, taking the lead role for this venture.

Other members of the AHI include the University of Queensland, the University of New South Wales at the Australian Defence Force Academy, and the Australian National University, along with the State Governments of South Australia and Queensland.

Also supporting the trial were the Australian Defence agencies of the Directorate of Trials, Aerospace Operations Support Group, Royal Australian Navy Ranges and Assessing Unit, and the Aircraft Research and Development Unit.

"The aim of the HyCAUSE trial," says the DSTO Program Manager Dr Noel Martin, "was to test a design for a supersonic combustion ramjet engine, known as a 'scramjet', operating at ten times the speed of sound and powered by hydrogen fuel. The internal shape of the engine, which contains no moving parts, is critical to the processes of mixing and combustion in order to generate thrust."

## Faster than jet turbines, cheaper than rockets

Scramjet propulsion technology has the potential to significantly improve on the capabilities offered by jet turbine and rocket engines.

Jet engines commonly fitted on aircraft today use a turbine to compress air for high-powered combustion. Scramjets, however, rely instead on supersonic forward motion for this essential process. Fuel is injected into the air stream and spontaneously ignites due to the massive temperature and pressure the gasses are under. The onset of combustion causes the gasses to expand and thus accelerates the exhaust air to speeds higher than the inlet gasses, thereby providing propulsion.

With scramjet engine technology, velocities more than about five times the speed of sound (Mach 5) are considered theoretically attainable, this being the slowest speed at which a craft can fly for scramjet combustion, with maximum speeds estimated variously to be as high as four times the lower limit. By comparison, the fastest long-haul airliners flying today have maximum speeds of less than Mach 1, and the fastest operational military aircraft, the Lockheed SR-71 Blackbird, had a top speed of about Mach 3.3 powered by two hybrid turbo-ramjet engines.

Furthermore, while rocket engines have long been able to deliver speeds equal to or better than those of scramjets, the advantage a scramjet offers is that it draws its oxygen from the atmosphere. A rocket, on the other hand, must carry oxygen as part of its fuel supply, constituting as much as 80% of the fuel load. A scramjet-powered craft can therefore be made smaller, lighter and faster, providing far greater range for the same fuel load.

However, one of several technical obstacles for the implementation of scramjets at this stage is that they can only operate when the internal flow of gasses is well above supersonic velocities. The vehicle platform carrying the scramjet therefore requires another form of propulsion to attain these speeds. Rocket power is typically used for this purpose.

## The HyCAUSE focus of study

The design issue addressed by the recent HyCAUSE trial was that of ensuring proper combustion at supersonic speeds in order to generate thrust.

Dr Martin puts it this way: "While a scramjet is mechanically very simple, consisting essentially of just a metal tube, it is vastly more complex aerodynamically than a turbine engine. The engineering challenges involve maintaining a supersonic airflow inside the engine, getting the fuel and air to combust properly, and generating more thrust than drag."

In the lead-up to the HyCAUSE trial, the scramjet design was arrived at using findings obtained from extensive ground-based shock tunnel activities plus valuable experience gained through previous flight tests (four HyShot launches).

HyCAUSE scramjet test flight launch at the Woomera Test Range facility.

The HyCAUSE flight test vehicle was built with the intention of further studying the fundamentals of supersonic combustion, leaving aside investigations into the development of net thrust at this stage of the experimentation.

Preparations for the trial at the test site required the attendance of DSTO staff several weeks in advance of launch day, with work continuing even up into the launch window phase when technical, logistical, and weather problems had to be managed.

The launch took place in near windless conditions with perfect visibility. Propelled by a two-stage rocket, the scramjet test vehicle was carried to a height approaching 500 kilometres. On its downward trajectory in freefall from space – the test phase of the project – it attained speeds approaching Mach 10, approximately 11,000 km per hour.

The scramjet combustion experiment took place in the last few seconds of travel before ground impact. During this time, data about the internal flow of gasses was gathered by temperature and pressure sensors mounted in and around the combustion chamber, with the sensor data transmitted to the ground stations. The test vehicle hit the ground, as planned, about 450 kilometres from the launch site.

## Results that pave the way to an exciting future

According to Dr Steven Walker, Deputy Director of the Tactical Technology Office at DARPA, “The test was notable for having gathered the first flight data ever recorded anywhere on a scramjet of inward-turning engine design. DARPA will compare this flight data to ground test data measured on the same engine configuration in the US.

“We are pleased with the significant progress being made by this joint effort between the US and Australia, and believe that a hypersonic airplane could be a reality in the not-too distant future,” he said.

A wide range of defence and civilian uses have been envisaged for vehicles powered by scramjet.

Hypersonic flight, powered by reusable air-breathing propulsion systems, may eventually offer a means of low-cost high-speed transport of people and equipment across the globe, with journey times that would be typically measured in only a couple of hours or less.

Because of the greater fuel economy of scramjet motors, they could be used instead of rockets to power high-speed missiles in cruise mode, and may also offer access to space flight on an ‘on-demand’ basis as well as a low-cost means of delivering payloads into low-earth orbit.



## DSTO and the Australian Hypersonics Initiative (AHI)

The AHI is a research collaboration facilitated by DSTO, with the technical lead role undertaken by Dr Allan Paull, formerly of the Centre for Hypersonics at the University of Queensland (UQ) and now with DSTO's Weapons Systems Division.

Dr Paull has been the technical leader of the HyCAUSE program since its inception, which began while he worked at the UQ. The University has been at the forefront of scramjet technology development globally for many years, having led the international HyShot program that demonstrated the world's first supersonic combustion in an atmospheric flight test at Woomera in 2002 at speeds approaching Mach 8.

Under Dr Paull's guidance, a DSTO branch for applied hypersonics research was established in Brisbane in 2007, leading to a considerable increase in DSTO's technical input into the HyCAUSE project. DSTO beforehand had already

Above left and right: the HyCAUSE scramjet test apparatus and launch vehicle rocket before launch.

Above centre: the DSTO HyCAUSE support team at Woomera.

been making important contributions to several work areas in hypersonics, such as computer modelling of the combustion processes, non-linear mechanics, guidance and control, trajectory analysis, telemetry collection and system studies.

In 2006, DSTO signed a \$74 million Hypersonics International Flight Research Experimentation (HIFiRE) Agreement with the United States Air Force, with up to ten hypersonic flight experiments planned for Woomera over the next five years.

Australian researchers working in a number of organisations have been developing scramjet projects for more than three decades, with active research programs in niche technologies of scramjet propulsion as well as guidance and control at hypersonic speeds, all of which have established Australia as a leading international player in the field.



# *Nulka* anti-ship missile decoy upgrade in progress

In a continuation of one of DSTO's most acclaimed research and development programs, the organisation is undertaking further work on the *Nulka* missile countermeasures device to improve its flight stability. Meanwhile, celebrations have been held to mark the hundredth installation of this system on a US ship.

*Nulka* is a ship-launched hovering rocket active decoy designed to defend against a wide variety of present and future radar guided anti-ship missiles. It does so by emitting a large radar cross section while flying a slow hovering ship-like trajectory to lure the attacking missile away from the ship.



The device was developed jointly by Australia and the United States, with DSTO producing the rocket vehicle including its unique hovering flight capability, and US researchers producing the electronics decoy capability. The program originated from DSTO's early work in ship self-defence against new generation sea-skimming missiles such as *Exocet*.

Initial sea trials were carried out in 1992 on HMAS Brisbane and USS John Hancock. The operational system underwent many evaluations at sea before introduction into the US Navy fleet in 1999 and acceptance into RAN service in 2001.

## Improving *Nulka*'s flight control

DSTO has for many years assisted the *Nulka* Program Office (NPO) and flight vehicle contractor, BAE Systems Australia, by conducting experiments to study current flight control unit performance and potential future upgrade paths.

BAE Systems is currently carrying out work on improvements to the flight control system that enables *Nulka* to maintain a stable upright posture in hovering flight, with an upgrade of this system being effected by installation of an Inertial Measurement Unit (IMU) device.

The IMU uses solid-state electronics rate sensors and accelerometers to perform the guidance functions formerly provided by physical mass spinning gyroscope mechanisms.

These IMUs, manufactured by US company Honeywell, feature new-generation technology known as Micro-Electro-Mechanical Systems (MEMS) that integrate mechanical elements, sensors, actuators, and electronics together into the tiny space of a silicon chip, using micro-fabrication techniques.

DSTO researcher Ashley Martin explains, "The MEMS IMU devices offer size, weight, power and ultimately cost advantages over other IMU technologies, and also offer some gains in accuracy.

"Furthermore, they can be reactivated, meaning that they can be tested and still be capable of carrying out a mission, whereas the current spinning mass gyros can only be used once, and then have to be removed from the vehicle for replacement or resetting," he says.

*Main photo: Nulka anti-ship missile decoy in flight.*

*Left: Acutronic flight simulation table rotating at high speed.*



### New study tools for *Nulka*

The newly installed flight control equipment, along with a flight control unit, was tested in a real-time flight simulation known as 'hardware-in-the-loop', conducted in a facility at DSTO.

The DSTO facility houses a recently acquired Acutronic three-degree of freedom motion table that allows continuous rotation in three axes.

The apparatus also features an enclosed chamber in which devices can be exposed during testing to temperatures ranging from 85°C to minus 55°C, making this the only one of its kind in Australia with the capability known as 'integrated environmental control'.

The table has been used to simulate typical *Nulka* flight motions while feedback signals from the IMU mounted on the table controlled the vehicle motion via the *Nulka* flight control unit.

Seen as ideal for hardware-in-the-loop testing as well as testing of MEMS-type IMUs, the capability is being further developed for other defence applications.

### *Nulka's* ongoing success story

In July this year, the hundredth *Nulka* system was fitted to the USS Gonzalez. The event was marked with a formal dinner held in Melbourne.

BAE Systems Australia, having acquired the licence from DSTO to commercialise and market the technology, has produced over 700 *Nulka* decoys for the Australian, US and Canadian navies achieving regular sales of between \$40 million and \$50 million dollars per year. The decoy is assembled in Australia from subsections produced in both the US and Australia.

Recognised as the 'gold standard' active missile decoy system worldwide, *Nulka* will also be fitted to the RAN's Air Warfare Destroyer, and is being considered for use on Amphibious Deployment and Sustainment vessels.

To date, *Nulka* has earned \$700 million in exports from sales to the US and Canada, making it Australia's most successful regular defence export.



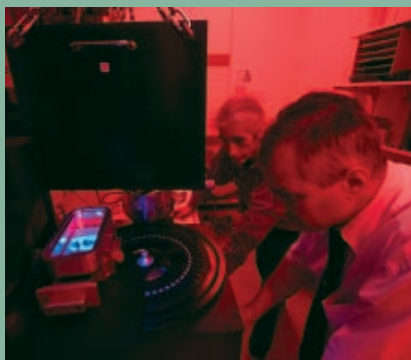
Above: Acutronic flight simulation table in stationary mode.

Below left: view of Acutronic flight simulation table as seen from the control room with DSTO researchers at work.

Below: *Nulka* launch from a naval vessel.



# Quantifying the impact of dirty little bombs



*Photon-counting Imaging System equipment used for luminescence at ANU.*

The detonation of a 'dirty bomb' containing radioactive material in an urban area is likely to produce panic in the general population. DSTO is developing ways to provide measures of exposure that will assist the recovery effort, and which will also enable investigators to examine other forms of ionizing radiation events.

While the world is yet to experience the impact of a dirty bomb explosion, it has already come very close to the real thing.

In the 1990s, two such weapons were assembled but not detonated by Chechen rebels; one in Moscow and one in Chechnya. Along with these all-but consummated terrorism attacks, many others have been shown to be in the planning. Recently, seven members of a British Al-Qaeda terrorism cell were convicted in England on charges of conspiring to build such a weapon.

Meanwhile, an incident of this kind has already occurred unintentionally. In 1987, a scrap-metal merchant in the Brazilian city of Goi  nas cut open a stolen canister of caesium chloride, dispersing highly radioactive dust-like material over a large area. This created widespread panic, causing health services to be inundated by people fearful of radiation contamination.

The lessons learned from this and other such experiences are that quantifying the radiation dose the population has been exposed to is a key part of recovery process measures, enabling treatment to be appropriately allocated and unfounded fears alleviated.

DSTO researcher Dr Barnaby Smith points out that dirty bombs are rightly referred to as 'weapons of mass disruption' rather than 'mass destruction'.

"Generally, the risk to health from radiation exposure is less than the public perception," he offers. "At the same time, on top of the injuries the blast causes, a state of citywide panic could exacerbate the crisis and even result in further casualties. A further form of ongoing disruption caused

by dirty bombs is to render the affected site off-limits for commerce and habitation, with decontamination cleanups taking possibly many years."

## Detecting radiation with luminescence measurement

The method being used by DSTO to ascertain levels of radiation exposure sustained by people involves the use of a technique known as recombination luminescence, which measures the radiation dose delivered to common building materials.

Dr Smith explains, "When any crystalline material is exposed to ionising radiation, electrons are ejected from their usual locations, and some get trapped in irregularities in the crystal lattice. The number trapped is proportional to the radiation dose received.

"Depending on the material and trapping sites, these electrons can remain trapped for periods ranging from seconds to millions of years. When, at a later stage, the material is heated or exposed to stimulating light, the trapped electrons are released, and some of them recombine at 'luminescence centres'.

"The emitted luminescence, given off as ultraviolet or visible light, can be measured using sensitive detectors, and this then is used to calculate the total radiation dose received since the crystal was last heated, such as by firing during the manufacture of pottery."

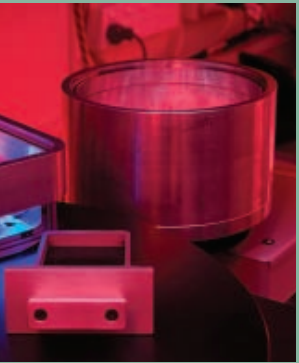
He adds, "Generally, analysis of fired materials is done by heating a portion of the sample, while unfired materials are analysed by stimulation with infrared or visible light."



## Dosages and dates revealed by luminescence

The use of luminescence readings as a means of dating began in the 1960s when the technique was first developed to measure the age of fired pottery artifacts from antiquity.

This technique exploits the fact that luminescence levels in crystalline materials are reset to zero when heated. After firing, radiation from naturally occurring radioactive elements in the object itself and its surrounds causes a slow accumulation of charge in the crystal lattices of the pottery.



To calculate the age of the object, the figure for total radiation dose absorbed by the specimen is divided by the radiation dose rate. The first figure is determined using luminescence readings from the pottery. The second is gained by measuring radiation emissions from the pottery and the surrounding environment. Since radiation dose is known to accumulate at particular rates, this can be used to quantify in yearly terms the radiation readings obtained from the object by luminescence.

Subsequent work has extended the applicability of the technique to crystal-bearing items such as bricks, tiles, and ceramics and also to porcelain objects, such as crockery, electrical and plumbing fittings.

More recently, luminescence has been applied as well to the process of dating non-fired material.

One of the most significant of these techniques is that of dating sediment deposits. By selecting quartz grains from the material, luminescence techniques are able to determine when the sediment grains were last exposed to sunlight (when their crystal clocks were last set to zero) and thus, the age of the deposit.

This technique is rapidly becoming a cornerstone method in geochronology, providing unique dating information on sedimentary deposits, and which can reach further back into time than carbon-14 dating techniques.

## Applications for radiation exposure analysis

The luminescence technique for non-fired materials can similarly be used to analyse radiation exposures to construction materials containing quartz materials such as mortar, concrete and gyprock, which provide a ready source of potential dosimeters in any urban environment.

In such a way, luminescence techniques are being used to map radioactive fall-out from nuclear detonations and accidents. The work has involved the collection of samples of brick and porcelain from the Chernobyl region, roof tiles in Hiroshima, and bricks from the USA and the former USSR.

Luminescence analysis of these samples gives a measure of total dose absorbed, which is compared with the current radioactive environment, determined from an analysis of surrounding materials and *in situ* measurements with a portable gamma spectrometer. The difference between the measured total dose and that attributable to the environmental sources is the dose that the samples have absorbed from the event of interest.

## **DSTO's depth of research experience in luminescence**

*Dr Barnaby Smith and fellow DSTO researcher, Dr Nigel Spooner, have worked since the 1970s on improving understanding of the physics involved as well as applications for the science, during which time, they have developed some of the underlying methodologies of the technique.*

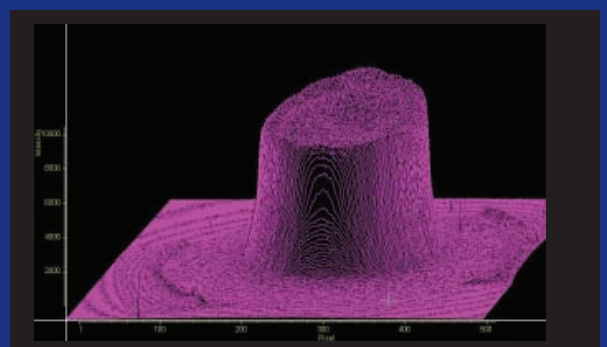
*They recently participated in a pilot program along with researchers from the University of Adelaide as part of an international study to measure samples from buildings near the Semipalatinsk nuclear test site in Kazakhstan for excessive radiation dosages.*

*Flowing from this work, they assembled a sampling kit and the necessary instrumentation to gather samples and data from the site of any future radiological event.*

*Their work on luminescence analysis has been facilitated by the presence in Australia of two unique instruments.*

*One is the Fourier transform '3D' spectrometer at the School of Chemistry and Physics at the University of Adelaide, and the other is the Photon-Counting Imaging System in the Research School of Earth Sciences at the ANU. These two instruments allow detailed analysis of the spectral characteristics and spatial distribution of luminescence emissions, which thereby greatly assists the development of new luminescence protocols for radiation dose measurement.*

*DSTO and the University of Adelaide are currently working towards the establishment of a Luminescence Analysis Centre of Expertise that will enhance national security capabilities in this area.*



Graphic of test results obtained from Photon-Counting Imaging System equipment.

# Major research facility inaugurated for future warfare studies



DSTO and the Capability Development Group in Defence have established a new facility known as the Joint Decision Support & Simulation Centre (JDSSC) to conduct research on strategic and capability development issues for the Australian Defence Force.

The centre is housed in a recently constructed purpose-built laboratory at Fairbairn in the ACT, with this site chosen to give national Defence planners headquartered in Canberra ready access to a means of investigating strategic, Joint Armed Services or whole-of-government issues, using simulation and experimentation techniques.

The creation of the laboratory will facilitate assessments of the feasibility, utility and limitations of innovative warfighting concepts in a secure controlled environment that integrates professional judgement, mathematical models, historical experience and field performance.

The new centre forms part of DSTO's Next Generation Battle Labs for its Network Centric Warfare and Joint Experimentation program under which clients, analysts, scientists and engineers can study future system requirements, explore new concepts and evaluate solutions.

DSTO researcher Jamie Watson, who heads DSTO's Experimentation Initiative, foreshadows big plans for the new centre. "In addition to being networked to DSTO's other simulation and experimentation laboratories, the JDSSC will eventually be connected with simulation and experimentation centres operated by the ADF Service divisions, Australian industry and research organisations overseas," he says.

"The facility will enable collaboration between these different sites through seamless interfacing that allows all participants to simultaneously share simulations, scenario visualisations, electronic seminar support and related analytical tools."

## Rationale for the JDSSC

The rationale for establishing the JDSSC arises from the many growing uncertainties in today's strategic environment. They in turn have required increasingly complex responses on strategy and capability matters from Defence decision-makers, and such responses commonly involve the joint use of force elements, adding a further element of complexity.

"To understand these intricacies," says Watson, "Defence has been making greater use of modelling and simulation tools for experimentation.

"DSTO was providing support to Defence decision-making in Canberra with some simulation models, but could not draw on the wider range of its experimentation capabilities outside of Canberra, or those of the ADF Armed Services and Defence industry partners. The facilities outside Canberra were of limited use anyway for developing concepts because they focused mostly on single-Service issues with little capability for study of joint issues.





*Above and inset right: experimentation exercise being conducted in the JDSSC.*

"With Defence strategy and capability decision-making largely based in Canberra, and set to become increasingly so with the Headquarters Joint Operations Command being located in the region too, the establishment of the JDSSC in the ACT as a national focus for experimentation was seen to address a number of pressing shortfalls," he says.

The JDSSC has been designed to assist with inquiries into primary defence matters including what range of capabilities Defence should invest in, how much of these is enough, what level of preparedness is required, and how Defence capabilities can be operated and maintained most efficiently.

### The JDSSC setup

The facility supports Defence decision-making by visualising, analysing and verifying.

It provides for seminar-type theatre level war-gaming with a significant human-in-the-loop component to investigate strategic issues, along with the simulation of models in a complex multi-asset environment for capability development and the study of operational issues. It also allows for a focus on modelling of individual assets for inquiries into tactics and procedures as well as training, mission rehearsal and operational planning.

A feature of the centre design is its flexibility, enabling facilities to be readily reorganised and reconfigured to meet different needs as they arise.

The JDSSC design also incorporates a mechanism for verifying outcomes and accrediting models to ensure that it provides a trusted way to support and inform decision-making.

Watson explains, "For the facility to serve any use, the outcomes must be believable. Accreditation of simulations and models is therefore an important issue."

Another set of issues that the facility developers are addressing are those arising from its intended relationship with industry partners, which is seen to be a key aspect of operation. These issues include the management of intellectual property, secondment of industry staff to the JDSSC and ways of making network connections with industry facilities.

The facility is intended to be used for experiments, seminars and workshops for about 30 weeks of the year.

In the longer term, it is envisaged that the JDSSC will be collocated within the Defence Research Centre in Defence's Russell offices, and that the ADF's Joint, Navy and Air Force simulation facilities will become permanent residents there.



# Setting fire to the MHC fuel tank for safety's sake

DSTO recently conducted fire resistance testing on the Ready-Use Fuel Tank fitted to the RAN's Minehunter Coastal (MHC) vessels to ensure the highest safety standards are maintained for the MHC fleet.

The trial, performed at the Werribee campus of the Victoria University in Victoria, was carried out using a representative thermally insulated composite test panel.

The work forms the third part of a joint program funded by the Mine Warfare and Clearance Diving System Program Office (MCDSPPO) of the Defence Materiel Organisation (DMO) to bring the MHC vessel 'into class' – meaning, to ensure that certain safety standards are met for structural performance in case of fire.

"Fire safety is the responsibility of the flag authority, in this case the RAN, and therefore the MCDSPPO is working with Det Norske Veritas (DNV) to ensure the highest level of safety is maintained for the MHC vessels," says DSTO researcher Zenka Mathys.

## Norwegian input for vessel classification

During the process of classifying the MHC, DNV, a Norwegian-based 'classification society' that sets technical safety rules and standards for maritime vessels and equipment, was asked to give an appraisal of the safety status of the vessel.

DNV identified certain areas that possibly lacked structural fire protection. These included various bulkheads and decks of the MHC as well as the Ready-Use Fuel Tanks, all of which are required to comply with a particular 'A-Class' fire resistance standard.

In the case of the Ready-Use Fuel Tanks, the level of requirement was classified as A-60.

DNV had suggested that if testing was not conducted to validate any proposed insulation, then double the amount of standard certified insulation would be required to meet the requirements – in which case, significant additional cost, weight and insulation volume would be necessary.

## DSTO fire resistance testing

Previous tests carried out by DSTO during last year included a small-scale fire test in July and a large-scale loaded fire test in September to study the effects of fire on structures like the engine-room deckhead.



*Apparatus for fire resistance testing at Werribee campus.*

The testing conducted in September on the representative deck showed that no additional insulation was required, so the MHC vessels have been found to comply with the International Convention for Safety of Life at Sea (SOLAS) in this regard without need for modifications.

The recent fire resistance test for the Ready-Use Tanks was conducted in accordance with the International Maritime Organisation FTP Code Resolution A.754 (18), with representatives from DNV, the Directorate of Navy Platform Systems (DNPS) and MCDSPPO present to observe.

The test panel was fitted with an insulation system prepared by COLPRO Pty Ltd, involving 2-layer Microtherm insulation, and lagged with silicone coated glass fabric to protect the insulation from fuel spillage and contamination, a consideration of particular importance in the diesel generator rooms.

The insulation used by DSTO, involving considerably less volume and weight of material and at lesser cost than the measures proposed by DNV, was found to provide the required level of fire protection.

After the trial, the results were analysed and a test report was submitted to MCDSPPO, with documentation also sent to DNV for consideration.

## All clear for fire safety

The work conducted by DSTO on the testing of the Ready-Use Fuel Tanks has resulted in an alternative form of insulation protection being identified and validated.

The outcome of the studies overall will result in significant savings in cost, weight and insulation volume required on the MHC vessels, since testing has shown no additional insulation is necessary for the deckheads, and a lesser volume is needed for tank protection than had been proposed by DNV.

This work forms part of a broader program to gain overall DNV safety certification for the MHC vessels.

## BRIEFS

### Structural testing of retired Orion wing

A retired high-usage RAAF TAP-3 Orion wing has been recently delivered to DSTO Melbourne for structural fatigue testing work.

Twenty sample pieces, known as structural test coupons, will be cut from the lower wing skin panel splices, each coupon being about 1 metre long by 0.4 metres wide.

The upper surface of the wing will also be used to research the understanding and management of corrosion in aircraft structures and to trial new non-destructive testing equipment.

The extraction of coupons from an actual wing will enable the fatigue study to be as realistic and representative as possible. The

coupons will be tested under spectrum loading representative of RAAF usage in a computer-controlled hydraulic uniaxial fatigue testing machine.

The purpose of the research is to confirm previous analysis results generated by the now completed P-3 Service Life Assessment Program and to further understand the critical features that limit the fatigue life of the RAAF AP-3C Orion wings.

The work is expected to reveal detailed information about the propagation of potential fatigue cracks in the wing lower surface panel splices.

As a result of testing, it is hoped that some conservatism in the current life limits could be eased.

The work will ensure that the timings of necessary ongoing structural inspections and eventual retirement of the RAAF AP-3C fleet are delayed for as long as possible, thereby maximising aircraft availability and reducing the cost of ownership.



Orion wing under structural test.

### Self-powering electrical storage vest under study

A proposal submitted by the CSIRO Textile and Fibre Technology division to develop a new-generation energy harvesting and storage garment for soldiers was accepted for investigation in the latest round of approvals for the Defence Capability and Technology Demonstrator (CTD) Program.

The vest-type garment incorporates a flexible integrated energy drive system with battery that accumulates electrical energy produced by the soldier's movement, thereby reducing the weight of batteries a soldier needs to carry to power personal electronic equipment.

Piezoelectric materials, which produce an electric current when deformed, are a core part of the system technology.

The same division of the CSIRO also successfully submitted another proposal for investigation involving a suit of wearable body armour made of carbon nanotubes that offers greater protection in a lighter and more comfortable garment.

The CTD Program, managed by DSTO, enables Defence and industry to collaboratively explore emerging technologies that show a potential to enhance Australian Defence Force capabilities, and to study the likely technical issues associated with acquisition of the technology.



Wearable rechargeable battery system.

### Measuring the tools that measure mental workload

DSTO and the University of Western Australia (UWA) have been exploring the capabilities of an instrument called the FaceLAB 4.2 Eye-Tracker for workload measurement.

Measuring mental workload is a key area of investigation in human factors research. The FaceLAB 4.2 remote eye-tracker system is one of the latest technologies developed for this purpose.

The study recently conducted by DSTO and UWA assessed the reliability and validity of the device as an instrument for measurement of mental workload by comparing its performance with other established mental workload metrics.

To carry out the research, human participants were given the task of operating an unmanned underwater vehicle (UUV) simulation, throughout which, ocular and physiological measurements were taken.

The study found that the 'percentage of eye closure' metric provided the most valid and reliable measure of the ocular workload metrics gathered by the FaceLAB 4.2.

The results of this work will further knowledge on current and future methods for the objective measurement of mental workload.

The project was undertaken as part of the Cooperative Education for Enterprise Development (CEED) program hosted by UWA.

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